19.4.5 Ex Situ Treatment

Ex situ treatment technologies include physical, chemical, biological, and thermal treatment methods that reduce the toxicity, mobility, or volume of a contaminant by altering its physical or chemical properties. The impacted media are conventionally or remotely excavated and handled before treatment. Remotely handled material may require remote treatment. While the waste volume may increase or decrease depending on the ex situ treatment method, contaminant mobility or toxicity may be reduced or eliminated through treatment. Exposure routes are generally eliminated once the media are excavated and removed.

19.4.6 Disposal

Disposal involves the placement of excavated material in an on-Site or off-Site permanent engineered waste management facility to restrict contaminant mobility and mitigate exposure routes. However, in some cases, excavated material may be stored in an engineered waste management facility for an interim period of time while awaiting shipment to a permanent disposal facility.

19.5 Identification and Screening of Technologies

The identification and preliminary screening of potentially applicable remedial technologies and process options for WAG 10 sites are described in this section. Remedial technology types and process options were identified for the GRAs discussed in the previous section and screened based on effectiveness, implementability, and cost. Both conventional and innovative and emerging technologies that have been demonstrated at a pilot scale are considered in this evaluation. The detailed evaluation of the screening criteria for each of the alternatives is found in Sections 19.5.1 through 19.5.7. The identification and screening for the remedial technologies considered for WAG 10 sites are shown in Table 19-6.

To evaluate effectiveness, the ability of each technology or process option to remediate the waste media and meet the RAOs was considered. Specific information considered includes the ability of the technology to handle the types and volumes of contaminated media, proven reliability of the technology relative to contaminants and conditions at the sites, and the potential impacts to human health and the environment during implementation. The effectiveness of each option was classified as high, moderate, low, or uncertain in Table 19-6.

To evaluate implementability, the technical and administrative feasibility of each technology was considered. Technical feasibility refers to technology-specific parameters that constrain effective construction and operation of the technology relative to site-specific conditions. Administrative feasibility refers to the capability to obtain required permits for on- and off-Site actions; the availability of treatment, storage and disposal services; and the availability of equipment and personnel required for implementing the technology. The implementability of each option was classified as high, moderate, low, or uncertain in Table 19-6. Some technologies with moderate to low effectiveness and/or implementability are retained because they may have application under certain site-specific circumstances.

Table 19-6. Screening of remedial technologies.

General Response Action	Remedial Technology	Technology Options	Effectiveness	Implementability	Relative Cost	Screening Result
No action	Environmental monitoring	Groundwater sampling	Not applicable	High	Moderate	Retain
		Air sampling	Not applicable	High	Low	Retain
		Soil surveys	Not applicable	High	Low	Retain
Institutional controls	Access restrictions	Fences	High; for institutional control period only and for human health risk reduction only	High for institutional control period only	Low	Retain
		Deed restriction	High; for institutional control period only and for human health risk reduction only	High, for institutional control period only, uncertain afterward	Low	Retain
	Administrative controls	Warning signs	Low; for human health risk reduction only	High	Low	Retain
		Awareness training	Low; for human health risk reduction only	High	Low	Retain
		Land use controls	Moderate; for human health risk reduction only	High	Low	Retain
Containment	Cap	Native soil cover	Not applicable to WAG 10 Sites	Not applicable to WAG 10 Sites	Not applicable to WAG 10 Sites	Reject
		Engineered barrier	Not applicable to WAG 10 Sites	Not applicable to WAG 10 Sites	Not applicable to WAG 10 Sites	Reject
Removal	Standard techniques	Excavation with conventional earth-moving equipment	High	High	Low	Retain
		Truck-mounted vacuum systems	High	High	Low	Retain
	Remote techniques	Robotics	Low	Low	High	Retain

Table 19-6. (continued).

General Response Action	Remedial Technology	Technology Options	Effectiveness	Implementability	Relative Cost	Screening Result
In Situ treatment	Physical and chemical	Stabilization or solidification	Not applicable to WAG 10 sites	Not applicable to WAG 10 sites	Not applicable to WAG 10 sites	Reject
	Biological	Phytoremediation	Not applicable to WAG 10 sites	Not applicable to WAG 10 sites	Not applicable to WAG 10 sites	Reject
Ex situ treatment	Physical separation	Screening	High	High	Low	Retain
		Flotation	High	High	Low	Retain
		Attrition scrubbing	High	High	Moderate	Retain
	Thermal treatment	Incineration	High	High	Moderate	Retain
	Chemical treatment	Fixation and stabilization	High	High	Moderate	Retain
		Soil washing	Moderate	Moderate	High	Retain
	Biological treatment	Composting	High	High	Moderate	Retain
UXO Detection	Magnetometers	Fluxgate magnetometers	Moderate/High	High	Moderate	Retain
		Proton precession magnetometers	High	Low	Moderate	Retain
		Optically pumped atomic magnetometers	High	High	Moderate	Retain
	Conductivity meters	Frequency domain conductivity meters	Low	Moderate	Moderate	Retain
		Time domain conductivity meters	High	High	Moderate	Retain
	Radar	Ground penetrating radar	Low	Low	Moderate	Retain
Disposal	Landfilling contaminated soil and debris on the INEEL	Central Facilities Area (CFA) Landfill	High	High	Low	Retain
		INEEL CERCLA Disposal Facility (ICDF)	High, though status is uncertain	Status uncertain – currently projected to be available in 2004 for soil and debris	Low	Retain
		Mass Detonation Area	High	High	Low	Retain

Table 19-6. (continued).

General Response Action	Remedial Technology	Technology Options	Effectiveness	Implementability	Relative Cost	Screening Result
	Disposal of contaminated soil and debris off the INEEL	Waste Management Northwest landfill in Arlington, Oregon	High	High	Moderate	Retain
		Onyx Environmental Services Treatment Complex in Port Arthur, Texas	High	High	Moderate	Retain

Relative costs were evaluated by comparing relative estimates of capital, operation, and maintenance costs. Engineering judgment was used to classify costs as high, moderate, or low, relative to other process options in the same technology type for each medium of concern.

19.5.1 No Action

Active remediation is not conducted under the No Action option. Environmental monitoring is the only activity considered for the No Action alternative. While the No Action GRA would not achieve RAOs established for WAG 10, it is retained to serve as a baseline for evaluating other remedial action alternatives.

Monitoring would include annual groundwater monitoring for NOAA and STF-02 sites and air monitoring and soil sampling for STF-02 and all TNT/RDX soil sites. Air monitoring may include particulate monitors to determine whether fugitive chemical contaminants escape from sites at which contaminated soil and debris are left in place. Air monitoring also would be implemented through an INEEL-wide program. Soil sampling would involve sampling and analysis within and around sites where contaminated soil is left in place to determine whether toxic organics or metals are mobilized to the surface or migrating to groundwater. There are no environmental monitoring activities appropriate for the UXO areas, and hence, no monitoring activities are included in the no action alternative.

Potentially, all of these monitoring technologies would be technically and administratively implementable. Costs of soil and air monitoring would be low, while groundwater monitoring costs would be moderate. All monitoring technologies shown in Table 19-6 pass the screening process and were considered further in the FS.

19.5.2 Institutional Controls

Institutional controls are defined in the DOE long-term stewardship study (2000a) as "Legal and other nonengineering measures intended to affect human activities in such a way as to prevent receptors from reaching residual hazards. Institutional controls include land and resource management, deed restrictions, well-drilling prohibitions, building permits, hunting licenses or permits, physical measures such as markers, and facility security." All of these controls reduce human health risks by preventing completion of the exposure pathway(s). Institutional controls typically do not reduce risks to ecological receptors. DOE (2000a) identifies nine categories of institutional controls including:

- Easement—A legal mechanism creating a limited interest in land belonging to another person (a positive easement), such as an easement granting access to conduct groundwater monitoring; or a limitation on the rights of the owner of the land (a negative easement), such as a prohibition on construction of housing.

- Deed Notification—A description in a property deed that conveys information about the property to future buyers (e.g., a notice that hazardous materials have been placed in a landfill on the property).

- Deed Restriction—A provision in a deed prohibiting certain uses of the property (e.g., a covenant that the property may never be used for housing). Certain deed restrictions may be enforceable through reversion clauses, which allow the former property owner (i.e., the federal government) to take back ownership of the property if terms of the deed restrictions are not followed.

- Lease—A document that outlines and restricts the conditions for temporary use of a property. Note that the Hall Amendment to the National Defense Authorization Act requires DOE to seek EPA concurrence on lease of DOE land on National Priority List (NPL) sites (DOE 2000b).

- Covenant—A promise by one landowner to another made in connection with a conveyance of property to use or refrain from using the property in a certain manner. Generally, covenants may be binding on subsequent landowners if (1) notice is given to the subsequent landowner, (2) there is a clear statement of intent to bind future owners, (3) the agreement "touches and concerns" the land, and (4) there is vertical and horizontal privity between the parties.

- Permit—a document that authorizes or prohibits certain land use activities (e.g., a building permit or a permit to withdraw groundwater) through approval by the appropriate federal, local, or state government entity. Permits do not affect property rights.

- Zoning—Police power use by local government to regulate or control the use of property by specifying zones or districts within which only specified uses or types of construction may occur as a means to implement a master plan.

- Sign—A marker that conveys messages regarding property and its use restrictions.

- Fence—A fixed structure used as a boundary or barrier to physical access.

Active institutional controls including facility security and other access restrictions, maintenance of fences and markers, etc., are assumed to be required for a minimum of 100 years following site closure. Institutional controls listed above may meet human health RAOs both during and after the 100-year institutional control period, either individually or in combination with other technologies and GRAs.

CERCLA 120(h) places specific requirements related to institutional controls on federal departments or agencies, including the DOE, prior to and after land transfer (DOE 2000b). These include:

- Notice of the types, quantities, and dates of hazardous substances known to have been stored, released, or disposed of at the site to the extent such information are known.

- Required content of deeds for transfer of real property include:

  - Notice of types and quantities of hazardous substances

  - Notice of the time at which storage, release, and/or disposal occurred

  - A description of the remedial action taken, if any.

- A covenant warranting that:

  - All remedial action necessary to protect human health and the environment with respect to any remaining hazardous substances has been taken before the date of transfer

- Any additional remedial action found to be necessary after the date of transfer will be performed by the United States government.

Five-year reviews are required under CERCLA for sites where hazardous substances remain on the site above levels that allow for unrestricted use or unrestricted exposure, to determine whether the selected remedy is still protective of human health and the environment. Five-year reviews would evaluate the effectiveness of institutional controls if selected as part of a remedy. Details of five-year review requirements are established in the ROD.

Any of these options are potentially implementable at OU 10-04 sites, based on current long-term stewardship planning (DOE 2000b). All of the options listed above are, therefore, retained for further evaluation.

19.5.2.1 Deed Restrictions. A deed restriction is a legally binding deed notice that limits the use of land at a given site. These restrictions prevent the completion of exposure pathways that would result in an unacceptable risk to human health, but are not effective in reducing ecological exposures.

Deed restrictions are effective and implementable only for the period of institutional control. Costs are relatively low. Deed restrictions were retained for further evaluation in the FS.

19.5.2.2 Physical Access Restrictions. Fencing is a physical barrier around a contaminated area that limits public access, and would be maintained for at least the 100-year institutional control period following site closure. Although fencing would reduce human health risk form direct exposure, fencing provides a small measure of site isolation form civilian trespassing. High chain-link fencing is highly effective in deterring entrance to the site by the population segment that is generally law-abiding and/or the casual visitor. For those who have a specific purpose to enter the site or do not respect fenced boundaries, fencing would be ineffectual. While this institutional control reduces risks to human health by limiting exposure to contaminated media, it is not effective in reducing ecological exposure. It is a viable technology for contamination that is not likely to become airborne. Signs are typically placed at the site to indicate restricted access.

This option is effective and readily implementable, with relatively low costs. Fencing has been retained for further evaluation in the FS.

19.5.2.3 Administrative Controls. Administrative controls can include awareness training, warning signs, and land use controls. Awareness training would consist of period public meetings or, for on-site workers, training classes, to explain the hazards associated with contamination, identify procedures to limit potential exposure, and identify actions to be taken in case of exposure. Warning signs would include information to warn the public and workers of hazards and describe actions to prevent exposure and provide a point of contact for notification in the event of accidental exposure. Land use controls could be imposed to restrict use of property in the public interest.

Although the implementability of training and warning signs is high and the cost low, the effectiveness is also low. Signs and awareness training are primarily meant to change the behavior of people such that contact with hazardous materials is reduced. However, signs may also act as an attractive nuisance and attendance at public training sessions can be low, although training of workers can be made mandatory and thus increase the effectiveness for risk reduction to on-site works. Land use controls that eliminate contaminated property from unrestricted use can be moderately effective; the implementability would be high and the cost low.

19.5.3 Removal

This GRA includes process options for excavating and removing contaminated media. Once removed, materials would be treated ex situ and packaged for disposal, or disposed of without treatment. An engineered facility located either on- or off-Site would be used for disposal. Removal options evaluated for WAG 10 include excavation with conventional earth-moving equipment, truck-mounted vacuum systems, and excavation using robotics.

19.5.3.1 Conventional Excavation. Excavation with hand shovels, backhoes, scrapers, loaders, bulldozers, and trucks represent standard excavation techniques using conventional equipment. Conventional earth-moving equipment has been demonstrated to be completely effective for removing contaminated soil to depths of up to 6.1 m (20 ft) at the INEEL. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. Costs are low and conventional excavation is technically and administratively feasible. Therefore, conventional manual and mechanical excavation is retained for further consideration.

19.5.3.2 Vacuum Extraction. Vacuum extraction uses the kinetic energy of a high-velocity air stream to penetrate, expand, and break up soil. Loosened soil and rocks are captured by a vacuum air stream and stored in a holding tank. The combination of a high-output compressor, efficient nozzle design, and strong vacuum make digging easier and faster in all soil conditions. The excavation head can remove 5 to 12.7 cm (2 to 5 in.) of soil in a single pass, pick up and pass rocks as large as seven inches in diameter, and trench as deep as 6.1 m (20 ft).

Wet or dry vacuum capability is used for difficult conditions in which a high-pressure water stream is needed to break up the soil. Addition of a heat source to the vacuum hopper allows separation of some contaminants from the soil. Commercial vacuum excavation units can be fitted with high-efficiency particulate air (HEPA) filtration for hazardous and radioactive applications.

Compared to standard excavation methods, use of soil vacuuming could greatly reduce the volume of soil excavated. It also would facilitate surface soil removal around facilities to which access is limited. Impacts to human health and the environment during removal activities likely could be minimized to allowable levels through administrative and engineering controls. This process option is technically and administratively feasible and costs are relatively low. This process option is retained for further consideration.

19.5.3.3 Excavation with Robotics. Excavation using robotics represents nonstandard excavation techniques using remotely operated equipment. While these technologies have been demonstrated at the INEEL, robotic excavation has not been globally demonstrated to be effective and implementable. Therefore, site-specific evaluation is required. Previous INEEL experience with contaminated site excavation demonstrates that this technology would reduce worker exposures and risks; however, costs are relatively high. However, the potential for significant risk reduction to the worker warrants consideration of remote methods for excavation of UXO. Therefore, this technology is retained for further consideration.

19.5.4 UXO Detection

The best military mine and munition detectors typically use one of three technologies, depending on whether ferrous or nonferrous buried munitions are being sought. When ferrous targets such as typical bombs and artillery projectiles are the objects of the search, then magnetometers are frequently used. When nonferrous targets such as many rockets, submunitions and landmines are objects of the search, then conductivity meters are better tools. In addition, ground-penetrating radar can be used to detect areas that may contain UXO.

There are several methods for performing UXO surveys using one or more of these detectors. The most common is manual ground search, which is very labor intensive. Various arrays of detectors have also been mounted on systems that can be towed behind a vehicle or flown on a helicopter. Recently, an airborne magnetometer system deployed on a commercial helicopter platform (the High-Sense Geophysics HM3™) was independently tested by the U.S. Army Corps of Engineers Environmental Support Center, Huntsville and the DOE's Oak Ridge National Laboratory (ORNL). Results indicate that airborne magnetic methods can be an appropriate tool for the detection of ordnance and for screening or characterizing large areas of suspected contamination (Gamey et al. 2000).

Airborne methods typically deploy sensors the same or similar to those used in ground-based surveys. Airborne surveys have been conducted at a number of sites around the United States under the direction and review of the U.S. Army Corps of Engineers. These surveys have been conducted under test/controlled conditions and over uncontrolled, uncharacterized sites. Although ground-based systems can ultimately yield more sensitive and thorough results, airborne surveys have been shown to reliably detect and characterize objects and collections of objects such as burn pits, gun ranges, bombing targets, and disposal sites, in addition to being able to locate numerous smaller isolated objects. It should be recognized that in addition to speed and cost, airborne surveys offer advantages over ground-based systems in being able to better handle certain conditions of topography and foliage. Testing and experience have shown that airborne surveys are appropriate and reliable for the screening and characterization of large areas for the presence of significant amounts of UXO in areas previously unrecognized as contaminated.

19.5.4.1 Magnetometers. Magnetometers were one of the first tools used for locating buried munitions and remain one of the best. Most bombs and gun shells contain a ferromagnetic metal such as iron that cause a disturbance in the earth's geomagnetic field. As buried ferrous munitions are influenced by the earth's primary magnetic field, a secondary magnetic field results, which magnetometers detect. Magnetometers must be sensitive enough to measure the weaker secondary magnetic field caused by a buried munition superimposed on the much larger natural geomagnetic background. Currently, three types of magnetometers are most often used to detect buried munitions: fluxgate, proton precession, and optically pumped atomic magnetometers.

19.5.4.1.1 Fluxgate Magnetometers—A fluxgate magnetometer measures the magnitude and direction of the magnetic field. They are inexpensive, reliable, rugged, and have low energy consumption. Fluxgate magnetometers have long been a standard UXO survey tool and are best used for rapid investigation by foot. Fluxgate magnetometers can detect single "munition-size" items (for purposes of this discussion, a cylindrical object with size ranging from that of a beverage can to a large loaf of bread) to a depth of 2 to 3 m (6.6 to 9.8 ft). However, they also are sensitive to small fragments and do not always discriminate well between small, shallow fragments and deeper, larger intact munitions. Most fluxgate magnetometers provide analog, rather than digital, output that makes it difficult to apply computer enhancement techniques. Fluxgate magnetometers continue to find wide application and are highly effective and implementable for locating surface and near-surface ferromagnetic items most often during screening operations. The cost is moderate.

19.5.4.1.2 Proton Precession Magnetometers—The proton precession magnetometer is based on the principle that magnetic fields can be inferred by measuring the movement of protons in a liquid such as water, kerosene, or other hydrocarbon. When the hydrogen nucleus (protons) in these materials are polarized then subjected to the ambient magnetic field, the frequency of procession of the protons will deviate from their natural frequency in proportion to the strength of the ambient field. This type of magnetometer is more sensitive than commonly used fluxgate magnetometers. The quality of the data collected by a proton precession magnetometer is dependent upon the time spent collecting each data sample. As a result, they are slower to use than fluxgate magnetometers. Proton precession magnetometers can typically detect single "munition size" items to a depth of 2 to 3 m (6.6 to 9.8 ft). While highly effective, the implementability of these magnetometers is low due to low sampling rate. The cost is moderate.

19.5.4.1.3 Optically Pumped Atomic Magnetometers—Optically pumped atomic magnetometers (also called atomic magnetometers or cesium vapor magnetometers) operate in a fashion similar to proton precession magnetometers except that the proton is replaced by an atom of a specific gas vapor, such as cesium or potassium. Atomic magnetometers are more sensitive and have faster sampling rates than proton precession magnetometers. Atomic magnetometers can typically detect single "munition size" items to a depth of 2 to 3 m (6.6 to 9.8 ft). Although atomic magnetometers are more expensive to purchase than the other two types of magnetometers, their high sensitivity, speed of operation and high quality digital signal output make them a good choice for situations where data fusion or digital processing is desired. Optically pumped atomic magnetometers are highly implementable and effective, and find wide application in magnetic mapping operations. The cost is moderate.

All magnetometers are retained for further evaluation.

19.5.4.2 Conductivity Meters. Conductivity meters are electromagnetic induction tools that, like magnetometers, are used extensively to detect buried munitions. Conductivity meters have an advantage over magnetometers in that they are not limited to detecting ferrous items. They are also useful in detecting nonferrous metallic items. When a metallic object is subjected to a varying magnetic field, eddy currents are induced within the object. Conductivity meters detect buried munitions by measuring the secondary magnetic field produced by these eddy currents. Because conductivity meters generate an electronic signal, they are "active" devices. Frequency domain and time domain are basically the two types of conductivity meters.

19.5.4.2.1 Frequency Domain Conductivity Meters—Frequency domain conductivity meters produce electromagnetic waves that pass through the subsurface, causing eddy currents to form. The intensity and phase of those eddy currents is a function of ground conductivity. Buried debris and disturbed soil have conductivities different from the surrounding natural soil. It is those conductivity differences that frequency domain conductivity meters detect. Frequency domain instruments are useful for detecting large buried caches of munitions, detecting disturbed earth associated with pits and trenches, and are the best geophysical tool available for detecting very small, very shallow objects such as the metal firing pins in plastic land mines buried just beneath the ground surface. However, because the resolution ability decreases dramatically with depth, frequency domain conductivity meters are not optimum for detecting individual, deeply buried munitions. Most commercial coin detectors are frequency domain conductivity meters. Frequency domain conductivity meters have limited application and low effectiveness for most UXO detection applications. The implementability and cost are moderate.

19.5.4.2.2 Time Domain Conductivity Meters—Time domain conductivity meters produce and measure an electromagnetic wave similar to that of frequency domain systems. The major difference is the waveforms used. Typically, a half-duty cycle, square wave, or pulse waveform is used, and measurements are made during the time the transmitter is off. The instrument locates metal by inducing a current in the ground and observing its decay with time. The detector portion of the instrument is tuned or timed to sense only a specific portion of the response curve, which greatly reduces noise and improves signal detection for buried metallic objects. Time domain conductivity meters provide a good compromise between precision and speed. Such instruments also provide a capability to locate all types of metallic munitions. Generally, they overlook small items such as nails or small munitions fragments, but will see typical intact munitions to a depth of 1 or 2 m (3.3 to 6.6 ft). Time domain conductivity meters are highly effective and implementable, and have wide application. The cost is moderate.

Conductivity meters are retained for further evaluation.

19.5.4.3 Ground Penetrating Radar. Ground penetrating radar (GPR) is another geophysical method used for subsurface detection of munitions. Like conductivity meters, they are "active" devices. A surface antenna produces a short pulse of microwave-frequency electromagnetic energy, which is transmitted into the ground. As the transmitted signal travels through the subsurface some of the signal strikes "targets" such as buried munitions or stratigraphic changes and is reflected back to the antenna. The depth of penetration of GPR is highly dependent on subsurface conditions. GPR can be effective to many meters in dry, clean sand, but is completely ineffective in saturated clays. Even small amounts of clay minerals in the subsurface greatly degrade GPR's effectiveness. GPR is slow to use, and the signal is usually difficult to interpret. Under optimum conditions, GPR can be used to detect individual buried munitions several meters deep. However, such optimum conditions seldom occur. GPR is normally more useful for detecting burial pits and trenches than individual items. It offers limited application and often low effectiveness for UXO operations. The cost is moderate and the effectiveness and implementability are both low. However, GPR is retained as it may prove useful under certain conditions.

19.5.5 Ex Situ Treatment

Ex situ treatment is applicable to excavated contaminated media. The treated materials are either disposed on- or off-Site. Relative to comparable in situ treatment technologies, ex situ treatment ensures that the effectiveness of the treatment process can be verified and that the contaminated media are treated to designated criteria. Ex situ treatment options potentially applicable to WAG 10 include physical separation using screening, flotation, or attrition scrubbing; thermal treatment; chemical fixation and stabilization; and soil washing. Each of these is described in the following subsections.

19.5.5.1 Physical Separation Using Screening. This technology takes advantage of the typical tendency of heavy metals to be distributed more into soil fines (silts and clays) than into coarse components (coarse sands, gravel, and cobbles). This is often the most effective separation step in a soil-washing process. Excavated contaminated soils can be passed through progressively finer screen sizes, using grizzly shakers or other standard process equipment, to separate fine-grained from coarse-grained fractions. This technology may be used alone or in combination with other treatment technologies to reduce the volume of contaminated soils for disposal.

This option is technically implementable using standard process equipment. Costs are relatively low. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. This technology is appropriate and effective for treatment of the STF-02 Gun Range soils and is retained for evaluation.

19.5.5.2 Physical Separation Using Flotation. Flotation separates fine-grained from coarse-grained soils by increasing their differences in settling velocities in a water clarifier and is applicable for contaminants that are preferentially partitioned on the fine-particle fraction of the soil. Soils are added to a conical tank filled with water, and air is introduced through diffusers or impellers. The air bubbles attach to the particulate, and the buoyant forces on the combined particle and air bubbles are sufficient to cause fine-grained particles to rise to the surface where they can be recovered by skimmers. Coarse-grained material settles to the bottom and is removed.

This option is technically implementable using standard process equipment. Costs are relatively low. Impacts to human health and the environment during operations could be minimized to allowable levels through administrative and engineering controls. This technology is applicable and effective for treatment of the STF-02 Gun Range soils and is retained for evaluation.

19.5.5.3 Physical Separation Using Attrition Scrubbing. Attrition scrubbing consists of mechanical agitation of soil and water mixtures in a tank to remove contaminants bound to the external surfaces of particles. This technology may be effective for lead removal from SFT-02 Gun Range soils. Treatability studies of representative soil samples from the STF-Gun Range would be required to determine the effectiveness of this technology, alone or in combination with other technologies, to reduce the volume of contaminated soils. Therefore the effectiveness is considered moderate.

This option is technically implementable using standard process equipment. Impacts to human health and the environment during operations could be reduced to acceptable levels through administrative and engineering controls. Costs are estimated as moderate. This technology is retained for further evaluation.

19.5.5.4 Thermal Treatment. This option would consist of incinerating excavated chemically contaminated soil at high temperatures to produce a stable inert waste form. Nearly total destruction of organic chemical contamination would occur. Therefore, disposal requirements after treatment would be minimal or nonexistent. The toxicity of heavy metals would not be reduced. Because of the volatility of lead and concerns with air emissions, there are strict waste acceptance limits on lead contamination, and hence the STF-02 soils and lead contaminated railroad ties are not considered candidates for incineration.

On-Site incineration is not administratively feasible and is screened from further consideration. There are several off-site thermal treatment facilities that could treat the TNT/RDX contaminated soils. For example, the currently operational Onyx Environmental Services incinerator in Port Arthur, Texas is a RCRA-permitted thermal treatment system that is also approved to accept INEEL. Incineration detoxifies organics and can achieve a waste volume reduction of 200:1. Review of the waste acceptance criteria for this incinerator indicated that the TNT/RDX soils expected to be generated during remediation can be accepted for treatment. Costs are estimated as moderate, and implementability is high. Therefore, this option is retained for the TNT/RDX contaminated soils.

19.5.5.5 Chemical Fixation and Stabilization. Chemical fixation and stabilization technologies immobilize hazardous constituents in waste by using additives that bind them into a solid waste form. Solidification and stabilization processes commonly are used to treat materials similar to the STF-02 Gun Range lead contaminated soils. While toxicity of lead would not be reduced, availability of the COC and exposure risks via soil ingestion and plant uptake would be reduced. Disposal of the treated STF-02 soils in a controlled landfill would be required. Volumes of contaminated media would increase by 30 to 50%. The proposed ICDF will include a treatment facility, the SSSTF, which will provide a stabilization process using Portland cement to treat soils characteristic for RCRA metals.

Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. The effectiveness and implementability of this option are high. Extensive handling and mixing of the soils would be required to produce a homogeneous waste form. However, standard construction and soil handling equipment could be used. Costs would be low to moderate relative to other ex situ treatment options. This option is retained as a possible treatment process for WAG 10 lead-contaminated soils only, because success has not been well documented for soils containing TNT and RDX.

19.5.5.6 Soil Washing. Soil washing is accomplished by contacting soil with a wash solution to mobilize the target metals from the soil, separating the soil and solution, and treating the solution. Acid leaching, a soil washing technology, is effective at removing lead from soil and is the technology process considered for evaluation. Acid leaching aims to solubilize metals from the soil by changing the pH. Adding acid lowers the pH and increases the supply of H^+ ions. The H^+ ions generated are consumed in a multitude of reactions that increase soluble metal concentrations.

Acid leaching can be conducted as a continuous process involving the following steps:

- Bringing acid and soil into contact in a leaching tank
- Separating the leached soil from the spent leachant
- Regenerating the spent leachant by precipitating the heavy metals.

The precipitated metals can be dewatered, and the resulting sludge is sent to an offsite smelter for recycling of the metal content. Acid leaching is a relatively slow process and requires large equipment. Acid leaching was successfully demonstrated to remove lead from soils at the small arms ranges at Fort Polk, Louisiana, in 1997, and the Twin Cities Army Ammunition Plant, Minnesota, from 1993 to 1995 (Battelle Columbus 1998; EPA 1997). Clean soils would likely be returned to the excavation site, and concentrated residual waste would be sent for recycle or properly disposed of either at an on-Site or off-Site landfill. If necessary, pH adjustments of soil would be performed prior to returning soils to the excavation sites.

Treatability studies would be required to determine the effectiveness of acid leaching for removing contamination from WAG 10 soils. Toxicity of the toxic metals would not be reduced. This technology would produce large quantities of secondary waste requiring treatment and disposal in a secure landfill. This process option is estimated to have high effectiveness for reducing risks to human health and the environment and meeting RAOs at the STF-02 Gun Range. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. The implementability and effectiveness of this option are moderate, but costs are high relative to other ex situ treatment technologies. This option is retained for further evaluation.

19.5.5.7 Composting. Composting would involve excavation of contaminated soil, removal of large fragments of TNT and RDX, adding other feedstocks to the soil, and periodically mixing the amended soil to promote biological degradation. The end product would be a contaminant-free humus that can be placed back on the land.

Through the composting process, naturally occurring microorganisms break down organic contaminants in the soil. Using the contaminants as "food," the microorganisms convert them into harmless substances consisting primarily of water, carbon dioxide, and salts. In addition to this food source, microorganisms require nutrients such as carbon, nitrogen, phosphorous, and potassium in order to thrive, digest, and reproduce. To provide these nutrients in sufficient quantities, soil amendments such as manure and potato waste are added to the contaminated soil.

Treatability tests will be required to determine the best mixture of contaminated soil and soil amendments to be used in the composting process. Numerous factors influence what mix of these ingredients provides microorganisms with the optimum environment in which to live. The most important of these factors is the carbon to nitrogen ratio. Other factors influencing the choice of soil amendments include moisture, pH, degradability, percentage of organic matter, and availability of specific soil amendments.

A variation to the conventional composting method was recently demonstrated at the INEEL (INEEL 2000) where the larger fragments of TNT were composted with the soil instead of being removed before treatment. In this process, the contaminated soil is pretreated with acetone to dissolve the TNT and RDX fragments. Soil amendments including manure, sawdust, and potato waste are then added and mixed for about 30 days.

Nearly total destruction of organic contaminants, including TNT and RDX, can be achieved. However, the toxicity of heavy metals will not be reduced. Therefore, this technology will only be considered for the WAG 10 TNT/RDX contaminated soil. This process option is estimated to have high effectiveness for reducing risks to human health and the environment and meeting RAOs at the TNT/RDX soil sites. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. The implementability and effectiveness of this option are high. Costs for conventional composting of TNT/RDX soils are low while costs for composting with acetone pretreatment is high. Both composting options are retained for further evaluation.

19.5.6 Disposal

The suitability of disposal facilities located on and off the INEEL is evaluated below for WAG 10 contaminated soils and waste.

19.5.6.1 On-Site Disposal at the INEEL. Two on-Site locations outside of WAG 10 could potentially be used for disposal of the chemically contaminated soils from WAG 10: (1) the CFA landfill, and (2), the proposed ICDF. The CFA landfill could be used for nonregulated debris and soils contaminated with toxic organics and metals at levels that exceed human health and ecological PRGs, but pass the RCRA toxicity characteristic leaching procedure (TCLP). The proposed ICDF could be used for disposal of radioactive and RCRA regulated waste as well as other nonregulated debris and soil (see Section 19.5.6.1.2). The Mass Detonation Area could be used for disposition of the TNT/RDX fragments and UXO. These three potential disposal locations are discussed below.

19.5.6.1.1 Disposal at the CFA Landfill—The CFA landfill is projected to continue to operate at least 10 to 15 years in the future. Soil and debris disposed at the CFA landfill must meet facility acceptance criteria (DOE-ID 1998) as well as state and federal regulations. This option is considered for TNT/RDX and non-RCRA hazardous lead contaminated soils and construction debris from the STF-02 Gun Range. Shrapnel and other debris from the UXO areas may also be disposed at the CFA landfill.

Characterization requirements would be minimal and could be met by collecting and analyzing samples during excavation. The CFA landfill accepts bulk shipments of industrial waste; therefore, no containerization would be required. The effectiveness of this option at WAG 10 is high because the contaminated media are removed from the area. This option is technically and administratively implementable. Costs are estimated as low. This option is retained for further evaluation.

19.5.6.1.2 Disposal at the Proposed INEEL CERCLA Disposal Facility—Currently, a repository for contaminated soil is being considered to consolidate INEEL contaminated soil. If implemented, the ICDF will probably be located at INTEC and is projected to become operational by the end of the year 2004. The ICDF would accept INEEL CERCLA soil and debris contaminated with radionuclides and RCRA-hazardous waste that meet the ICDF waste acceptance criteria (WAC) (in development). All WAG 10 waste addressed in this RI/FS is CERCLA-generated and is, therefore, ICDF candidate waste. The conceptual design incorporates disposal capacity for all currently identified ER CERCLA-generated remediation waste, including WAG 10 waste, and includes surplus capacity for currently unidentified remediation waste. No prioritization on the basis of activity, risk, etc., is currently planned. The ICDF will also include a treatment facility, the SSSTF, which will provide a stabilization process to treat soils contaminated with RCRA metals using a Portland cement-based agent. The stabilized waste will pass TCLP prior to disposal at the ICDF. The status of this facility is still uncertain because regulatory approval has not been obtained, funding has not been allocated, and the proposed facility is still in conceptual development. Currently, disposal costs at ICDF are not planned to be billed to the originating WAG; instead, the ICDF will cover the costs for the overall INEEL ER program. Characterization to meet the ICDF WAC, and transportation from the point of generation to the ICDF, would be the significant disposal costs. Transportation costs would be much less for this alternative than for any off-Site disposal alternative, because of the proximity of the ICDF to the points of generation of remediation waste, and characterization costs will likely be similar to those for off-Site disposal. Therefore, overall ICDF disposal costs will be lower than overall costs for any off-Site disposal alternative from the perspective of WAG 10. This option is retained for further consideration pending a final decision.

19.5.6.1.3 Disposal at the Mass Detonation Area—The Mass Detonation Area is located 1.6 km (1 mi) east of Mile Marker 8 on Lincoln Boulevard. It is north of INTEC and approximately 3.2 km (2 mi) east of the Naval Reactor Facility. The site has been used for a number of small to large scale sympathetic and mass detonation tests with test shots ranging up to 22,700 kg (500,000 lb) of explosives. The site includes nine blast craters varying in dimensions from a few feet to tens of feet. Although the site is not used for routine detonation tests, it is presently used to detonate any unstable and energetic material (i.e., TNT and RDX) and UXO that is detected on-Site and deemed safe for transport to the Mass Detonation Area; it is not used for disposal of contaminated soil or other waste materials. This option is technically and administratively implementable. Costs are estimated as low. This option is retained for further evaluation.

19.5.6.2 Off-INEEL Disposal. There are several disposal facilities located outside of the INEEL that are potentially suitable for disposal of contaminated soil from WAG 10. For example, the Waste Management Northwest landfill in Arlington, Oregon and the industrial waste disposal units at the Onyx Environmental Services Treatment Complex in Port Arthur, Texas, which are also approved to accept INEEL waste. The Waste Management Northwest landfill is a privately owned and operated treatment and disposal facility for industrial and hazardous waste. This facility is located approximately 885 km (550 mi) from the INEEL and is permitted to accept industrial and RCRA regulated waste. The disposal units are RCRA-compliant with independent liner and leachate collection systems. The Onyx Environmental Services Treatment Complex is located approximately 3,218.6 km (2,000 mi) from the INEEL and is permitted to treat industrial and hazardous waste, and dispose of nonhazardous industrial waste. Although other facilities are available, these are considered for cost estimation purposes in this feasibility study.

The use of the Waste Management Northwest disposal facility and the Onyx Environmental Services Treatment Complex by WAG 10 will depend on available disposal capacity, the ability of WAG 10 waste to meet waste acceptance criteria, and the continued operation of the site under permit and license from the State of Oregon and Texas, respectively. Waste Management Northwest and the Onyx Environmental Services Treatment Complex are accessible by rail from the INEEL, obviating intermodal transport.

Impacts to human health and the environment likely could be minimized to allowable levels through administrative and engineering controls during transportation from INEEL to the facility. This process option is, therefore, technically and administratively implementable, and effective. Relative costs for this option are moderate. Off-INEEL disposal is therefore retained for further consideration.

19.5.7 Summary

The environmental monitoring process options that were retained include air, soil, and groundwater monitoring. Institutional control actions include fences and legal restrictions (e.g., deed restrictions).

The representative removal technologies considered include standard construction equipment such as shovels, backhoes, and bulldozers as well as vacuum extraction.

Because heavy metal contamination cannot be destroyed, ex situ treatment options for soils contaminated with lead were evaluated based on their ability to immobilize or remove lead and reduce the overall volume of contaminated soils. Physical separation of metal fragments followed by stabilization or soil washing are the only feasible methods that meet this criterion. Ex situ thermal treatment and composting were retained for further consideration in treatment of the TNT/RDX contaminated soils.

Geophysical methods for detection of buried UXO considered include magnetometers, conductivity meters and GPR. Visual methods are also retained for detection of surface UXO.

The on-Site disposal locations that were retained for further evaluation include the CFA landfill, the Mass Detonation Area, and the proposed ICDF. The off-Site disposal facility retained for further analysis is the Waste Management Northwest landfill in Arlington, Oregon.

19.6 References

15 USC § 53, *United States Code,* Toxic Substances Control," Subchapter I, "Control of Toxic Substances."

42 USC § 9601 et seq., *United States Code*, October 21, 1976, "Resource Conservation and Recovery Act."

40 CFR 300, *Code of Federal Regulations*, Title 40, "Protection of the Environment," Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan."

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Silciliano, S. D. and C. W. Greer, 2000, "Plant-bacterial combinations to phytoremediate soil contaminated with high levels of 2,4,6-trinitrotoluene," *Journal of Environmental Quality*, 29: 311–316.

Section 20

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FIGURES

TABLES

20. DEVELOPMENT OF ALTERNATIVES

The technologies selected in Section 19 were combined to develop a range of response actions appropriate for WAG 10 contaminants and site conditions that exceed risk-based criteria for human health or the environment. A set of alternatives was developed to address each of the following:

1. TNT/RDX-contaminated soil sites (i.e., NODA, Firestation, NOAA, Mine/Fuze, and Experimental Field Station)

2. Lead-contaminated soil and debris at the Security Training Facility (STF)-02 Gun Range

3. UXO areas.

20.1 Response Actions for TNT/RDX Contaminated Soils

Four major remedial alternatives were developed to address trinitrotoluene (TNT)/Royal Demolition Explosive (RDX) contaminated soils: no action; limited action; removal and disposal; removal, ex situ treatment, and disposal. The major combinations of technology process options associated with each alternative are presented in Table 20-1. Each of the three remedial alternatives is discussed below.

20.1.1 Alternative 1: No Action

Formulation of a no action alternative is required by the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) (40 CFR 300.430[e][6]) and guidance for conducting feasibility studies under CERCLA (EPA 1988). The no action alternative serves as the baseline for evaluating other remedial action alternatives. The alternative includes environmental monitoring, but does not include any actions to reduce potential exposure pathways, such as fencing, deed restrictions, or administrative controls (EPA 1988).

20.1.2 Alternative 2: Limited Action

The limited action alternative represents the continuation of current management practices at WAG 10 soil sites and also includes site inspection and monitoring. Air monitoring and groundwater monitoring would be performed under INEEL Sitewide programs. Remedial actions under this alternative focus on restricting access (i.e., fencing, deed restrictions, and administrative controls), conducting soil sampling where TNT and RDX contamination remains in place, and performing routine monitoring for potential problems such as animal burrowing or erosion. If necessary, surface water diversions would be implemented to prevent surface water from accumulating at the site.

The effectiveness of the limited action would be evaluated by DOE-ID, the EPA, and the IDEQ during subsequent 5-year reviews. Additional environmental monitoring would be defined if determined necessary.

20.1.3 Alternative 3: Removal, Treatment of TNT/RDX Fragments, and Disposal of Soil

Removal, treatment of TNT/RDX fragments, and disposal of soil alternatives for WAG 10 TNT/RDX-contaminated sites consist of a geophysical survey for unexploded ordnance (UXO), if required, followed by removal of any detected UXO. Contaminated soil will be excavated by hand, and the fragments of TNT and RDX will be manually segregated from the soil unless safety analysis indicates it is safe to use conventional mechanical soil excavation and screening equipment. The fragments of TNT

Table 20-1. Remedial alternatives for TNT/RDX contaminated soil sites.

Technology Process Options	1 No Action	2 Limited Action	3a Remove, On-Site detonation of TNT/RDX Fragments, Dispose On-Site	3b Remove, On-Site Detonation of TNT/RDX Fragments, Dispose Off-Site	4a Removal, On-Site Detonation of TNT/RDX Fragments, Off-Site Soil Incineration and Disposal	4b Removal, On-Site Composting of Soil, On-Site Detonation of TNT/RDX Fragments, Return Soils to the Excavation Sites	4c Removal, On-Site Composting of Soil with Solvent Pretreatment, Return Soils to the Excavation Sites
Groundwater sampling	X	X	X	X	X	X	X
Air sampling	X	X	X	X	X	X	X
Soil surveys	X	X	X	X	X	X	X
Fences	—	X	X	X	X	X	X
Deed Restrictions	—	X	X	X	X	X	X
Administrative Controls	—	X	X	X	X	X	—
Hand Excavation	—	—	X	X	X	X	X
Manual segregation of TNT and RDX fragments	—	—	X	X	X	X	—
Excavation with conventional earth-moving equipment	—	—	X	X	X	X	X
Mechanical screening of RDX and TNT fragments	—	—	X	X	X	X	—
Field screening for TNT and RDX	—	—	X	X	X	X	X
Onsite detonation of TNT and RDX fragments	—	—	X	X	X	X	—
Onsite windrow composting	—	—	—	—	—	X	—
Onsite composting with solvent pretreatment	—	—	—	—	—	—	X
Onyx Environmental Services Treatment Complex, Port Arthur, TX	—	—	—	—	X	—	—
CFA landfill	—	—	X	—	—	—	—
INEEL soil repository disposal	—	—	X	—	—	—	—
Waste Management Northwest landfill, Arlington, OR	—	—	—	X	—	—	—
Return soil to excavation sites	—	—	—	—	—	X	X

and RDX will be detonated on-Site at the Mass Detonation Area. The soil will be disposed on the INEEL or at a permitted off-Site facility. Verification sampling would be conducted at the removal sites to ensure that all contamination at concentrations exceeding preliminary remediation goals (PRGs) was removed. The excavations exceeding 0.3 m (1 ft) in depth would be backfilled with clean soil following the excavation. Shallow excavations would be recontoured to blend with the existing landscape. Institutional controls would be implemented and to restrict access and monitoring would be performed because buried, undetected UXO and TNT/RDX fragments could exist after remediation. Frost heave and erosion could bring these items to the surface in the future and pose an unacceptable risk. Under Alternative 3a, the excavated soils would be disposed on-Site at the INEEL, while under Alternative 3b excavated soils would be disposed off-Site. These alternatives are discussed in the following subsections.

20.1.3.1 Alternative 3a: Removal, Treatment of TNT/RDX Fragments and On-Site Disposal of Soil at the INEEL. Implementation of this alternative would require excavation of all soils concentrations that are above PRGs, segregation of the TNT and RDX fragments with subsequent detonation at the Mass Detonation Area, and the transport of the soils to an INEEL waste disposal facility such as the proposed INEEL CERCLA Disposal Facility (ICDF) or the CFA landfill. The ICDF is currently under review by stakeholders. If the repository is developed, it would open for receipt of soils in the year 2004. Though the CFA Landfill was selected for evaluation in this feasibility study (FS), other INEEL facilities can be considered, such as the ICDF if appropriate, based on factors such as facility waste acceptance criteria, available capacity, and cost.

20.1.3.2 Alternative 3b: Removal, Treatment of TNT/RDX Fragments and Disposal of Soil Off the INEEL. Implementing this alternative would involve excavation of all soils with concentrations above PRGs, segregation of the TNT and RDX fragments with subsequent detonation at the Mass Detonation Area, and the transport of the soils to a private off-Site disposal facility. The most likely off-Site disposal location would be the Waste Management Northwest landfill in Arlington, Oregon, which receives RCRA waste and industrial nonhazardous waste. This landfill is located approximately 885 km (550 mi) from the INEEL in Gilliam County, Oregon. Compliance with appropriate waste characterization, transportation, and possible treatment requirements would be required under this alternative.

20.1.4 Alternative 4: Removal, Ex Situ Treatment, and Disposal or Returned to Excavations

Removal, ex situ treatment, and disposal alternatives for WAG 10 TNT/RDX contaminated sites consist of a survey for UXO, if required, followed by removal of any detected UXO. Contaminated soil and fragments of TNT and RDX will be excavated by hand unless safety analysis indicates it is safe to use conventional mechanical soil excavation and screening equipment. The soil will be incinerated at a permitted off-Site facility or treated biologically on-Site. Verification sampling would be conducted at the removal sites to ensure that all contamination at concentrations exceeding PRGs was removed. The excavations exceeding 0.3 m (1 ft) in depth would be backfilled with clean soil following the excavation. Shallow excavations would be recontoured to blend with the existing landscape. Institutional controls would be implemented to restrict access and monitoring would be performed since buried, undetected UXO and TNT and RDX fragments could exist after remediation. Frost heave and erosion could bring these items to the surface in the future and pose an unacceptable risk.

Under Alternative 4a, the TNT and RDX fragments will be segregated from the soils during excavation and detonated at the Mass Detonation Area. Then the contaminated soils would be incinerated and disposed at a permitted off-Site facility. Under Alternative 4b, the TNT and RDX fragments will be segregated from the soils during excavation and detonated at the Mass Detonation Area, then the contaminated soils would be composted on-Site and returned to the excavation sites. Under Alternative 4c, the soil and TNT and RDX fragments will be excavated together. The soil with the fragments of explosive will be treated according to the method developed at the INEEL by Dr. Frank Roberto and reported in the treatability study report "Waste Area Group 10 RDX/TNT CERCLA Treatability Study Final Report," (INEEL 1999). This treatment involves pretreatment of the soils with the fragments of TNT and RDX in a reactor with a solvent such as acetone to dissolve the fragments. The soil will then undergo biodegradation in the reactor by addition of compost material and periodic mixing. The treated soil will then be returned to the excavation sites. These alternatives are discussed in the following subsections.

20.1.4.1 Alternative 4a: Removal, Off-Site Incineration and Disposal. Implementing this alternative would involve excavation of all soils with concentrations above PRGs, segregation of the TNT and RDX fragments with subsequent detonation at the Mass Detonation Area, and transport of the soils to a private off-Site incineration and disposal facility. The most likely off-Site incineration and disposal facility would be the Onyx Environmental Services Treatment Complex at Port Arthur, Texas. Compliance with appropriate waste characterization and transportation requirements would be required under this alternative.

20.1.4.2 Alternative 4b: Removal, On-Site Soil Composting, and Return of Soil to the Excavations. Implementing this alternative would involve excavation of all soils with concentrations above PRGs, segregation of the TNT and RDX fragments with subsequent detonation at the Mass Detonation Area, and on-Site treatment by composting in a temporary portable building at a central location, such as the CFA. Composting will involve the addition of soil amendments, such as manure, sawdust, and potato waste to the contaminated soil. The amended soil will be placed into windrows and turned several times a day with special mixing equipment. After treatment the soils would be returned to the excavation sites.

20.1.4.3 Alternative 4c: Removal, On-Site Soil and TNT and RDX Fragment Composting, and Return of Soil to the Excavations. Implementing this alternative would involve excavation of all soils with concentrations above PRGs along with the TNT and RDX fragments, and on-Site treatment by homogenization of soil, solvent dissolution of the TNT and RDX fragments in a reactor, addition of compost materials, mixing, and soil sampling until TNT and RDX concentrations were reduced below the PRGs. A temporary portable building would be purchased, and a reactor would be constructed for this treatment. It is expected that acetone would be used as the solvent to dissolve the TNT and RDX fragments. About 208 L (55 gal) of acetone are required to treat one ton (1 yd^3) of soil. Solvent recovery and reuse is not considered feasible due to the hazards associated with distilling acetone that also contains TNT and RDX. Therefore an air emission control system capable of destroying acetone vapors will be required. The solvent pretreatment and composting would be constructed and performed at a central location, such as CFA. Treatment of each batch of soil is expected to take about 30 to 40 days. When soil sampling indicated the TNT and RDX concentrations are below PRGs, the soils would be returned to the excavation sites.

20.2 Response Actions for STF-02 Gun Range Lead Contaminated Soils

Three major remedial alternatives were developed to address the lead contaminated soils: no action, limited action, ex situ treatment and disposal or return of treated soils to the excavation sites. The major combinations of technology process options associated with each alternative are presented in Table 20-2. Each of the three remedial alternatives is discussed below.

Table 20-2. Remedial alternatives for STF-02 Gun Range lead contaminated soils.

Technology Process Options	1 No Action	2 Limited Action	3 Excavation, Mechanical Screening, Soil Stabilization, Metal Recycle, Encapsulation and disposal of railroad ties, On-Site Disposal of wooden building , asphalt pads, and treated soil	4 Excavation, Mechanical Screening, Soil Washing, Metal Recycle, Encapsulation of railroad ties, On-Site disposal of wooden building and asphalt pads, Return Soil to Site
Groundwater sampling	X	X	—	—
Air sampling	X	X	—	—
Soil surveys	X	X	—	—
Fences	—	X	—	—
Deed Restrictions	—	X	—	—
Administrative Controls	—	X	—	—
Excavation with conventional earth moving equipment	—	—	X	X
Mechanical screening to separate metal fragments and bullets from soil	—	—	X	X
Soil stabilization	—	—	X	—
Soil washing	—	—	—	X
Waste Management Northwest landfill, Arlington, OR	—	—	X	X
INEEL soil repository	—	—	X	X
CFA landfill	—	—	X	X
Metal recycle	—	—	X	X

20.2.1 Alternative 1: No Action

Formulation of a no action alternative is required by the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) (40 CFR 300.430[e][6]) and guidance for conducting feasibility studies under CERCLA (EPA 1988). The no action alternative serves as the baseline for evaluating other remedial action alternatives. The alternative includes environmental monitoring, but does not include any actions to reduce potential exposure pathways, such as fencing, deed restrictions, or administrative controls (EPA 1988).

20.2.2 Alternative 2: Limited Action

The limited action alternative represents the continuation of current management practices at WAG 10 soil sites and also includes site inspection and monitoring. Air monitoring and groundwater monitoring would be performed under INEEL Sitewide programs. Remedial actions under this alternative focus on restricting access (i.e., fencing and deed restrictions), conducting soil sampling where lead contamination remains in place, and performing routine monitoring for potential problems such as animal burrowing or erosion. If necessary, surface water diversions would be implemented to prevent surface water from accumulating at the site.

The effectiveness of the limited action would be evaluated by DOE-ID, EPA, and IDEQ during subsequent 5-year reviews. Additional environmental monitoring would be defined if determined necessary.

20.2.3 Alternative 3: Removal, Ex Situ Treatment, and Disposal or Returned to Excavations

Implementation of this alternative would involve excavation of the berms and surroundings soils with concentrations greater than PRGs, mechanical screening to remove metal fragments and bullets, recycle of the metal as allowed by DOE policy, treatment of the soils with subsequent disposal on-Site or return to the excavation sites. Conventional excavation and screening equipment would be used under this alternative. Verification sampling would be conducted to ensure that all contamination at concentrations exceeding PRGs was removed. Excavations exceeding 1 ft in depth would be backfilled with clean soil following the excavation. Shallow excavations would be recontoured to blend with the existing landscape.

In addition, the railroad ties used to support the targets would be removed, encapsulated, and disposed at a RCRA-approved landfill, such as the Waste Management Northwest landfill in Arlington, Oregon, or the ICDF, which will be a RCRA-compliant landfill. The small wooden building and asphalt pads would be removed and disposed at the CFA landfill.

Under Alternative 3a, the metal fragments and bullets will be mechanically screened from the soils and sent for recycle. The lead-contaminated soils will then be sampled. If determined to exceed the PRG and the RCRA lead toxicity characteristic limit, the lead-contaminated soils will be stabilized and disposed on-Site at the CFA landfill, the proposed ICDF, or other approved facilities on or off the INEEL. If the soils have concentrations that exceed the PRGs but are not RCRA toxic for lead, the soils will be disposed without treatment at the CFA Landfill, the proposed ICDF, or other approved industrial landfill on or off the INEEL. If the soils do not exceed the PRGs and the RCRA toxicity limit for lead, they will be returned to the excavation sites without treatment.

Under Alternative 3b, the metal fragments and bullets will be physically separated from the soils and sent for recycle if allowed by DOE policy. As much particulate metal will be removed physically from the soil as possible. The lead-contaminated soils will then be sampled, and if determined to exceed PRGs and the RCRA lead toxicity characteristic limit, they will be washed with an acid until the PRG concentration for lead is achieved and returned to the excavated sites. The soil washing secondary waste will be treated and disposed on-Site. If the soil concentrations exceed the PRG, but are not RCRA toxic for lead, the soil will be disposed without treatment at the CFA Landfill, the proposed ICDF, or other approved industrial landfill on or off the INEEL. If the soils do not exceed the PRG and the RCRA toxicity limit for lead, they will be returned to the excavation sites without treatment

Figures 20-1 and 20-2 show the processes that could be used for physical separation and soil washing by acid leaching for the STF-02 Gun Range soils. These alternatives are discussed in the following subsections.

20.2.3.1 Alternative 3a: Removal, On-Site Stabilization, and Disposal. Implementing this alternative would involve excavation of all soils with concentrations above, mechanical screening to segregate the metal fragments and bullets, and treatment of soil by stabilization if sampling indicates the soil exceeds PRG and the RCRA lead toxicity limit. Treated soils would be disposed on-Site at the CFA landfill, the proposed ICDF or other approved facility on or off the INEEL. Soil not exceeding the PRG and the RCRA lead toxicity limit would be returned to the excavation sites. If the soil concentrations exceed the PRGs, but are not RCRA toxic for lead, they will be disposed without treatment at the CFA landfill, the proposed ICDF, or other approved facilities on or off the INEEL.

The bullet-impregnated railroad ties would be encapsulated and disposed at a RCRA-approved landfill, such as the proposed INEEL soil repository or the Waste Management Northwest landfill in Arlington, Oregon. For disposal at the INEEL soil repository, the encapsulation would be performed on-Site. For off-Site disposal, the railroad ties would first be transported to Waste Management Northwest landfill in Arlington, Oregon, and encapsulated prior to disposal. The wooden structure would be demolished and disposed at the CFA landfill. The asphalt pads would also be excavated and disposed at the CFA landfill

20.2.3.2 Alternative 3b: Removal, On-Site Soil Washing, and Return of Soil to the Excavations. Implementing this alternative would involve excavation of all soils with concentrations above the PRGs, physical separation to remove metal fragments and bullets, and on-Site treatment of the soil by washing it with acid to remove lead if sampling indicated the soil exceeds the PRG and RCRA toxicity limits for lead, treatment and disposal of any secondary waste, and return of the treated soil to the excavation sites. If the soils do not exceed the PRG and RCRA lead toxicity limit, they will be returned to the excavation sites without treatment. If the soils exceed the PRG, but are not RCRA toxic for lead, they will be disposed without treatment at the CFA landfill, the proposed ICDF, or other approved facilities on or off the INEEL.

The disposition of the railroad ties, wooden building, and asphalt pads would be the same as described under Alternative 3a.

20.3 Response Actions for UXO Areas

Three major remedial alternatives were developed to address UXO areas: no action, limited action, and detection with removal and disposal of detected ordnance shown in Figure 19-3. The major combinations of technology process options associated with each alternative are presented in Table 20-3. Each of the three remedial alternatives is discussed below.

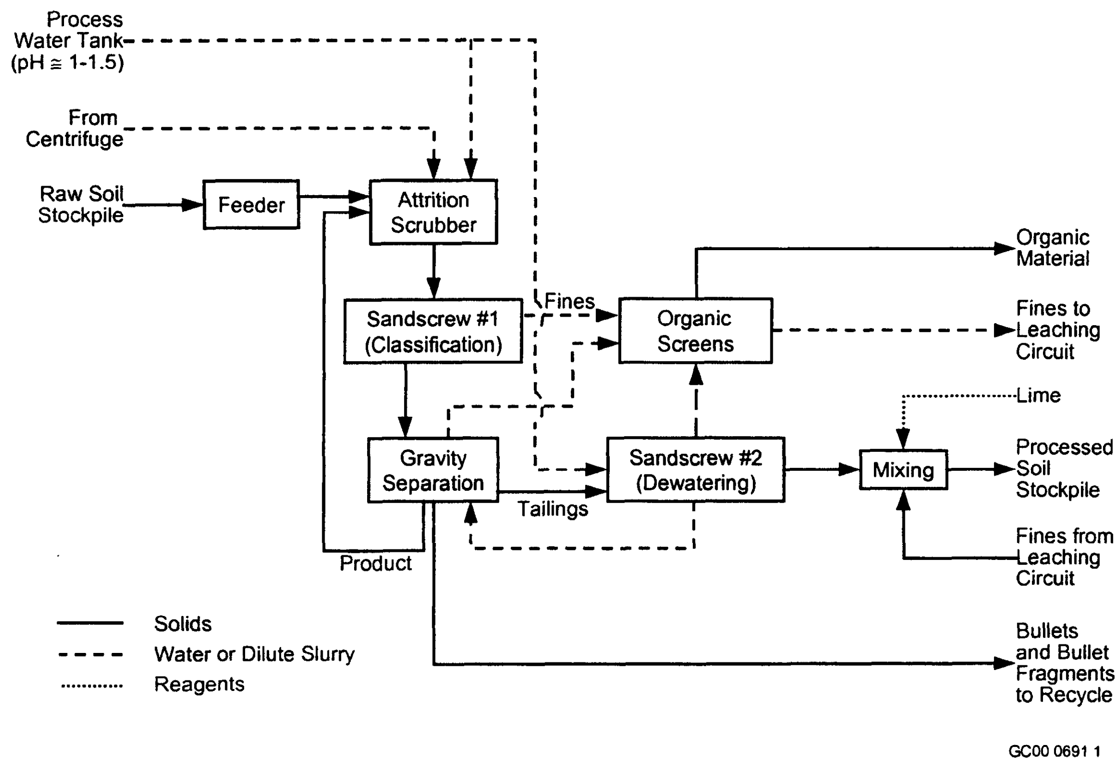

Figure 20-1. Potential physical separation process for STF-02 Gun Range soils.

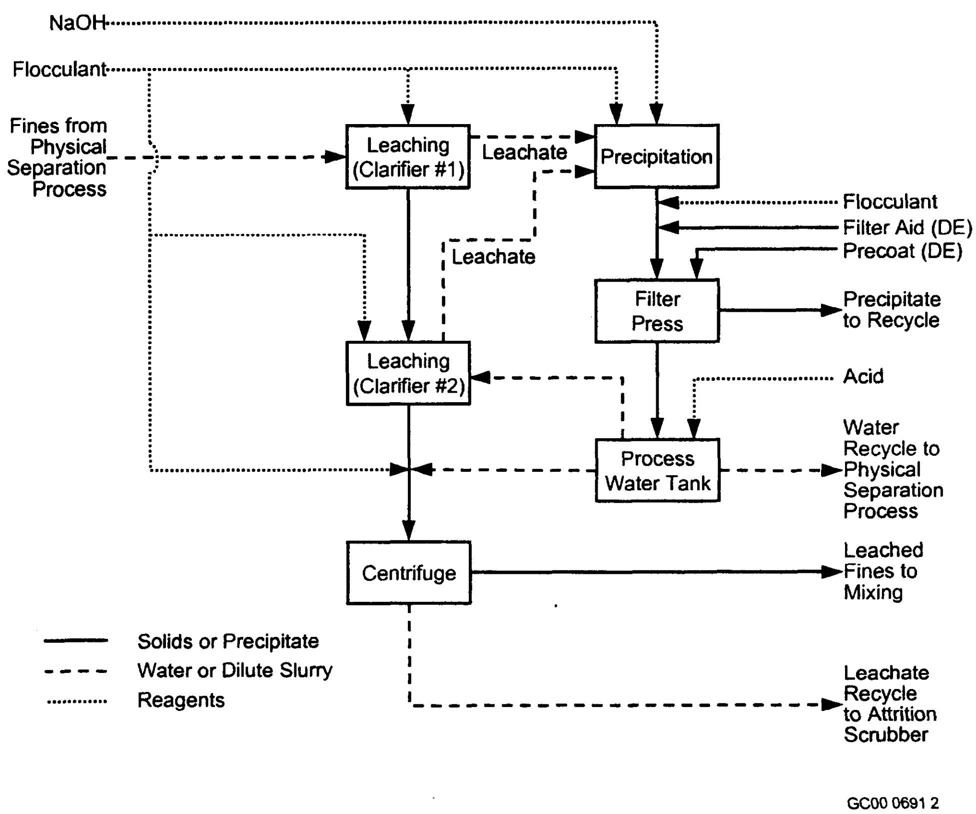

Figure 20-2. Potential soil washing by acid leaching process for STF-02 Gun Range Soils.

20.3.1 Alternative 1: No Action

Formulation of a no action alternative is required by the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) (40 CFR 300.430[e][6]) and guidance for conducting feasibility studies under CERCLA (EPA 1988). The no action alternative serves as the baseline for evaluating other remedial action alternatives. The alternative includes environmental monitoring, but does not include any actions to reduce potential exposure pathways, such as fencing, deed restrictions, or administrative controls (EPA 1988).

20.3.2 Alternative 2: Limited Action

The limited action alternative represents the continuation of current management practices at WAG 10 sites including site access restrictions, inspection, and monitoring. Remedial actions under this alternative focus on restricting access (i.e., fencing, deed restrictions, administrative controls), and performing surveys for UXO detection as required when activity on sites with suspected UXO is planned. The effectiveness of the limited action would be evaluated by DOE-ID, EPA, and IDEQ during subsequent 5-year reviews. Additional environmental monitoring would be defined if determined necessary.

20.3.3 Alternative 3: UXO Detection with Removal and Institutional Controls

Implementation of this alternative would involve aerial and/or ground surveys of all areas indicated on Figure 19-3 for UXO detection, removal of identified UXO, and institutional control. For this FS, an aerial UXO platform on a helicopter using cesium magnetometers for primary UXO detection and differential GPS for the precise UXO location was assumed to be performed as reconnaissance to identify potential UXO sites beyond the known UXO areas. For localized activities (i.e, soil sampling, excavation, or construction) the aerial methods of detection would be augmented with ground surveys using magnetometer sweeps and visual observations to identify and remediate UXO problems. Site reviews would be conducted every 5 years to evaluate the effectiveness of the UXO surveys and the need for additional survey and removal actions.

Table 20-3. Remedial alternatives for UXO Areas.

Technology Process Options	1 No Action	2 Limited Action	3 UXO Detection, Removal, and Institutional Controls
Deed Restrictions	—	X	X
Administrative access restrictions	—	X	X
Aerial surveys for UXO	—	—	X
Ground surveys for UXO	—	—	X
UXO removal	—	—	X

20.4 References

40 CFR 300.430, "Remedial investigation/feasibility study and selection of remedy," *Code of Federal Regulations,* Office of the Federal Register, July 1, 2000.

EPA, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, EPA/540/G-81/004, Office of Emergency and Remedial Response, U. S. Environmental Protection Agency.

INEEL, March 1999, *Waste Area Group 10 RDX/TNT CERCLA Treatability Study Final Report*, INEEL/EXT-99-01043, Rev. 0.